Chapter 7: Future perspectives

Introduction

This final term project was the second one to work on the pneumatic robot; in fact, it filled in some of the proposals for improving the robot mentioned in the first thesis dissertation [1]. The other future perspectives which were handled in this work and which were not implemented thus far remain valid, but they will not be repeated here. Most of the future perspectives that will be discussed implicate more sophisticated processing techniques, which will put an extra load on the computer controlling the robot. As the speed of this computer is already posing problems now, it may be clear that a faster model will be required for most of the presented future perspectives.

Blackboard control architecture

The presently used control architecture, which is basically a serial SMPA architecture, is a quite simple solution and therefore, lacks some power to deal with an increasing dataflow in real-time. To address this problem, it may be suited to implement a complete blackboard control architecture as this approach enables parallel processing of all the different modules. This way, the ultrasonic measurement, camera target tracking and measurement, sensor fusion, map building and path-planning component would all be considered as separate threads sharing their information through the blackboard. It may be clear that timing and controlling problems make the actual implementation of such a structure quite a challenge. At present, the blackboard parallel processing technique is only used to integrate the camera target tracking process with the rest of the robot control program and to enable an emergency stop procedure.

Zooming Target Tracking

If the target-tracking algorithm were to have a zooming capability, objects could be recognised and tracked at greater distances. This feature wasn’t implemented during the time of this project due to problems concerning the knowledge of the internal working of the target tracking algorithm and other problems concerning the adaptation of the camera control and distance measurement routines.

Extending the task of the camera

The camera is presently only used to search for and to follow the target object. This task could be extended with an assignment to retrieve information about the surroundings. In this connection, the
presented robotic application could be combined with earlier developed algorithms to extract features such as a distinction between road and bush, the recognition of walls, a white line, or even a human face.

**Use of a stereo camera**

The use of a stereo camera would open the way for a more accurate distance measurement and some applications that are more sophisticated, as already mentioned above. In fact, it was the idea to work with a stereo camera for this final term project, but due to delivery problems, a “normal” camera had to be used instead.

**Multiple ultrasonic sensors**

If more ultrasonic sensors could be used, this would mean that the robot would gain much more information about its surroundings at a time. Now, the robot’s field of view is extremely limited as the two sensors used provide only information about the environment straight ahead. Using more ultrasonic sensors would implicate having better maps, the possibility to work with topological maps and to use other means of path planning. On the other hand, it would pose a new challenge to intelligently fuse the now more complex data flow. In this context, an interesting option is to use multiple sensors as receivers for one measurement, coming to a tri-aural ultrasonic sensor architecture as shown on the following image:

![Figure 61: Tri-aural sensor array](image)
Chapter 7: Future perspectives

The central sensor is used both as a transmitter and a receiver, the two peripheral ones only as receivers. Using the phase-shift of a reflected signal over the three sensors, a far better angle measurement is possible than with a normal sensor configuration. By applying neural network techniques on the returned sensor data, as explained in [22], qualitative information can be retrieved out of the environment.

**Object recognition with ultrasonic sensors**

A common problem of ultrasonic sensors is that they are unaware of what they are actually measuring. This must not be accepted without posing questions. When looking at nature, some animals such as dolphins and bats show that it is perfectly possible to recognize preys, or in the robots’ case objects, using ultrasonic sensors. A procedure for achieving object recognition is based upon the analysis of the returned echo in the frequency domain. Another way is to make use of the envelope function, which is a simple graph of the returned analogue signal. An example of both characteristics is shown below:

![Figure 62: Power Spectral Density diagram and Envelope – function](image)

These characteristics can be recognized by a fuzzy neural network and can thus lead to the recognition of the reflecting object.

**Proximity sensors**

In its current condition, the robot is actually blind at close distances, since neither the ultrasonic sensors, neither the camera provide useful data at this range. Of course, the bumper switches are still present but firstly they are still quite unreliable and fragile and secondly, one could state that it is already too late when they return a signal. Therefore, it may still be a good idea to add some sensors based upon other physical principles of measurement such as infrared or tactile sensors.
Chapter 7: Future perspectives

Define multiple behaviours

If one could find a way of improving the robots’ perception of the environment (by adding more sensors), this could benefit the robot intelligence, as in this case, one can think about defining multiple behaviours. These behaviours could result in the robot being capable of accomplishing multiple abstract tasks instead of just walking towards a target. Moreover, by shaping the robot intelligence in this way, the resulting behaviour could be turned more logical and the movement speed could be upgraded.

Use topological maps

Topological maps are far more sophisticated than grid maps, so they pose an interesting challenge for future projects. They could not be implemented thus far, as they require more complete sensor data and also data of a higher quality. However, once this problem is solved, one should strive to make use of topological maps to speed up the map building process and to make intelligent and meaningful maps. A vast multitude of paradigms exists for the practical implementation of topological maps, as topological maps are still a field of much research.

Intermediate positions possible with pistons

One of the main problems limiting the robot in its applications is that it is only capable of raw binary movements: steps are always 23cm and rotations are always 16°. To improve the spatial resolution of the robot, an interesting improvement would be to build a system to control the pressure to the pistons, using pulse width modulation. This would enable the cylinder, and thus also the robot, to reach intermediate positions.

Gripper

Now the robot is capable of walking towards a certain target object, the logical next step is to grab this object and to return it to the user. This can sadly enough not be done by simply adding a gripper to the robot in its current state as the lack of spatial resolution doesn’t allow the robot to position itself precisely enough for such an operation. Another problem would be that the robot would not “see” this target object to be gripped as it would be at a too close range, so it may be clear that some other improvements stated above must be realised first before a gripper can be added to the robot, given one can find a suited insertion location for it on the robot.